PORT LABOUR CHALLENGES AND OPPORTUNITIES IN THE ERA OF PORT AUTOMATION AND DIGITALIZATION.

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ABSTRACT: The maritime and port industry experiences significant changes due to technological, operational and organizational developments. The paper investigates current and future challenges for port labour in the light of the main trends shaping the port competitive environment. In this perspective, the evolution of port labour is argued to be driven by technology related factor, i.e., digitalization and automation. Digitalization can increase port efficiency through improved port operations due to process standardization, increasing quality in port services and effective strategic planning. These trends are shaping a new framework creating new challenges and threats for port labour, given the increasing demand for new jobs focusing on high-skilled personnel. The paper demonstrates that, the expected transition "from strength to skill", will require new capabilities for workers, and consequently specific training schemes and certifications. The paper contributes on the ongoing debate on the challenges and the opportunities that technology brings into the port industry.

1. INTRODUCTION

The maritime and port industry are facing significant challenges due to technological, operational and organizational developments, creating a new setting for port labour. The adoption of new technologies such as Big Data, Internet of Things (IoT), Blockchain along with the increasing adoption of digitalization and automation, are challenging contemporary ports. These technological and operational developments have made it possible to obtain better results in terms of port productivity, labour productivity as well as improvements in the structure of work processes, in the quality of the port product, such as the activities carried out in the port context, and in safety and security standards.

Development, in organizational terms, also played an important role in improving the port context and the resulting port labour. The integration of existing information and communication systems (ICT) and data sources in the port context and their optimal organization represents an important driver in port development. For this purpose, the alignment between the port strategy and the digital strategy combined with the cooperation and collaboration between the actors operating in the port allow to reach a higher level of innovation. The increasing amount of new data and information creates new challenges for ports, requiring greater organizational complexity. The use of innovative technologies, tools, software, and methods allowing greater flexibility represents a fundamental driver for organizational change.

The labour scheme adopted by the port and especially the relationship between employers and employees represents another driver for organizational development that can foster port development. De Martino et. al. (2013) in their literature review argue that relationship networks are of strategic importance in determining the success of port development strategies.

Port operators are keep investing in new technologies, tools and methods aiming at increasing port productivity and their competitiveness in a highly competitive market, especially taking into account that ports play an important role in global supply network (Bichou and Gray, 2005) where ICT are essential for supply chain visibility (Gagatsi et al., 2013). The development of new knowledge (e.g., investments in training and education) and technologies (e.g., Port Community Information System) allow ports to reach higher level of attractiveness (as logistic nodes) and competitiveness.

These changes brought port labour at the forefront and at the epicentre of port related initiatives. In the era of digitalization and port automation, the development of new hard and soft skills is essential for enhancing the productivity and the efficiency of port labour. The aforementioned technological trends are shaping a new framework for port labour, due to the increasing demand for new jobs focused on high-skilled personnel, posing also challenges for existing port personnel.

The paper aims at providing an overarching theoretical framework for assessing how technological trends are shaping port labour. It deals with the new features characterizing the port labour in order to identify the future challenges to be faced by port workers and the possible solutions to these challenges. Following the introductory section, section 2 reports on the evolution of port labour, which is argued to be guided by technology-driven trends, i.e. digitalization and automation, as well as by the development of new hard and soft skills in the maritime-port context. Section 3 summarizes future challenges that port workers will face. In Section 4, grounding on the proposed conceptual framework addressing the new characteristics of port labour, the paper discuss the advantages and disadvantages in the technological development of ports, before concluding.

The paper pursues the two following research objectives that are:

- RO1: To identify the implications of digitalization trends in port labour.
- RO2: To identify the implications of automation trends in port labour.

2. LITERATURE REVIEW

Port labour is changing due to new dynamics that are shaping the contemporary port environment. In this perspective there are, six major categories of drivers for change which are: i) increasing port competition (see, for example, De Langen and Pallis, 2006); ii) liner shipping strategies (see Cariou, 2008); iii) technological developments (Ganesan et al., 2016; Niederman et al., 2007); iv) commercialization; v) new organizational models; vi) expanding containerization. These drivers are significantly affecting port operations, whose nature is shifting from capital intensive to labour intensive. Port labour have to respond and adapt to the new changes in the port context. The evolution of port labours is argued to be guided by technology-driven trends, i.e., digitalization and automation (Satta et al., 2019; Cariou, 2018; Fruth and Teuteberg, 2017; Martin-Soberon et al., 2014).

Digitalization and automation are valuable enabling technologies, shaping the new Industry 4.0 paradigm. This revolution describes the shift from asset operator to service orchestrator, generating more value for port operators (McKinsey & Co, 2018). It notably grounds on the implementation of new digital technologies and automated system in order to improve general working conditions,

quality of strategic plans and business model, communication with stakeholders and productivity (e.g., PwC, 2016). As of mid-2018, 47 container ports worldwide were partially or fully automated (Rodrigue, 2018). Recent initiatives and projects towards automated ports include the NxtPort, an information sharing platform developed by the port of Antwerp, the Port of Los Angeles's TraPac terminal and the New Qianwan Container Terminal at the Port of Qingdao.

This new technological paradigm facilitates and supports the improvement of several operations and procedures, which involve port labour. In this perspective, digitalization has been argued to enhance high level of port efficiency, safety and energy saving in the maritime-port context (Cariou, 2018), while automation has been demonstrated to guarantee the standardisation of port operations and a consequent greater level of efficiency, productivity and quality in port processes (Martin-Soberon et al., 2014). In this perspective, the familiarization with data gathering, monitoring of activities, track & trace operations and automated systems appear to be fundamental for port labour, strengthening further the efforts of the port operator to develop new business models and reinforce the competitiveness of the port.

2.1 Digitalization

The term digitalization refers to a sociotechnical process of applying digitizing techniques to broader social and institutional contexts (Tilson et al., 2010). This enabling technology, through its business applications is expected to significantly increase port efficiency either via automation of port operations (see for example the automated RWG container terminal at the port of Rotterdam) or via automation of port processes (see for example the Port Community System of the port of Hamburg operated by DAKOSY), to improve future planning and to support port responsiveness to port users' needs (via for example better utilization of the available equipment, real time information flow etc.)., even though the development of port e-services (Marianos et al., 2011).

Digitalization grounds on the adoption of innovative technologies and related tools such as: i) Big Data (e.g., reducing energy consumption), ii) Internet of Things (e.g., helping in developing an efficient way for managing port traffic, cloud-analytics), iii) Blockchain (e.g., secure system for collecting containers in the port) and (iv) the development of digital supply chains (e.g., for optimising port logistics chain). The adoption of the aforementioned digital technologies allows to better measure, monitor, and control port operations (at port complex or port terminal level). Technological innovations represent indispensable tools for improving the management of real time information related to vessel, trucks, passengers and goods in and out the port (Carlan et al., 2017) with the purpose of assuming optimal decisions concerning the availability of equipment, space, labour and other scarce port resources on the short and long-term.

"Big Data is a term that describes large volumes of high velocity, complex and variable data that require advanced techniques and technologies to enable the capture, storage, distribution, management, and analysis of the information" (TechAmerica Foundation's Federal Big Data Commission, 2012). In this perspective, one of the most important facilitators of Digitalisation is the use of Big Data (i). In the port industry Big Data can be used for reporting (Hamalainen and Inkinen, 2017) on several port operational issues such as financial and operational efficiency, damage control etc., although these technologies are making their first steps in the port industry (Heilig et. al., 2017).

Internet of Things (IoT) (ii) is defined as "a conceptual framework that leverages on the availability of heterogeneous devices and interconnection solutions, as well as augmented physical objects providing a shared information base on global scale, to support the design of applications involving at the same virtual level both people and representations of objects" (Atzori et al., 2017; p.137). Therefore, IoT, "enables things to talk" (Bassi et al., 2013) and provides everywhere and always a real time connection between people and things, through internet. As in the case of Big Data, also the IoT has not been widely applied in the port industry with the examples being limited. An IoT platform has been developed for the Port of Rotterdam Authority dealing with hydro and meteo conditions. The system, in use since the beginning of 2019, uses an extensive network of sensors to provide accurate and up to date water and weather data, allowing for a more efficient vessel's operation.

The Blockchain technology (iii) is increasingly scrutinized by both scholars and practitioners as a viable tool for redefining business models and operations adopted in the maritime and port domain. For example, it could allow to label containers with a cryptographic hash for their identification (Foroglou et al., 2015). In a broader perspective, blockchain technology will allow for more efficient and transparent transactions, eliminating the need for (trusted) intermediaries (Schmidt and Wagner, (2019). Blockchain can reduce the time needed for documentation for vessel's and cargo clearance, an issue that is among the major obstacles for the Short Sea Shipping.

Finally, the development of digital supply chains (iv) represents a key concept for optimising port logistics, ensuring storage of manufacturing goods and commodities, reducing transit time and maximizing cargo value in the transport chain (e.g., Du and Bergqvist, 2010).

2.2 Automation

When it comes to automation in businesses and processes, scholars argue that "industrial automation consists in the use of mechanic, hydraulic, pneumatic, electric electronic and computerised elements or systems to control equipment and processes, thereby reducing the involvement of humans in such activities" (Martin-Soberon et al., 2014; p.195). In the port domain, the first terminals experiencing automation processes have been those operating in the container industry, given some of their specificities. In this business, in fact, higher level of standardisation in container handling activities could be reached. Moreover, the business is characterized also by a high level of interchanges and high impact of technology on the efficiency of the terminals. In this perspective, the Port of Rotterdam in 1993 introduced the concept of "automated terminals" to refer to the highest level of automation currently applied, i.e. automated movements in the yard and dock-yard interchanges (Martin-Soberon et al., 2014; p.196).

In this vein, some anecdotal evidences suggest that innovations in automation can increase the standardization of port operations driving to greater efficiency, productivity and quality in port-related processes. According to Journal of Commerce (2018) yard productivity at a major container terminal in Hong Kong could be increased by 40% with the introduction of automated technologies while an article in Port Strategy (2018) mentioned that among the benefits that a port can experience via the adoption of increasing automation are better operational control and consistency, lower overall terminal operational costs and increased operational productivity. Nonetheless, nowadays, only about 1% of major ports are fully automated and only 2% are semi-automated (Drewry Maritime Research,

2018). The degree of automation differs among ports based on their peculiar characteristics. The initial investment cost, the yard requirements (land availability), various operational challenges, the shortage of specialised technical personnel, lack of data and data quality, the port labour perceptions and the power of the Unions, the port efficiency targets, are parameters affecting a port's decision on the adoption of automation in port's production and administration processes.

The port of Rotterdam is the first port in the world with automated terminals and with automated guided vehicles (AGV). The container terminals of Rotterdam, APMT and Rotterdam World Gateway (RWG) at Maasvlakte 2 represent the world's most automated terminals, operating largely autonomously allowing a growing expansion in the container business. An example of semi-automated terminal is the Vado Ligure Terminal, in North Western Italy, which will become operational at the end of 2019 and it will be the first semi-automated port in Italy with a fully-automated gate and stacking yard.

It is expected that by 2020 about 100 ports will be fully automated (Matinlauri, 2016). Terminal automation can result in time and cost reductions through increased efficiency and less human resources needs, with the latter being in some cases the reason behind recent conflicts between labor Unions and port/terminal operators. The Unions' fears is based on the fact that further technological developments in port automation can deteriorate their jobs. With self-driving trucks, automated RMGs in the container stacking areas and even remote control of container gantry cranes being already a port reality, further port automation is seen as a direct threat for their job safety.

2.3. New hard and soft skills

Innovation cannot be restricted to the adoption of new technologies; indeed, innovation is evident also in the development of new hard and soft skills. In particular, the notion of soft skills includes non-technological dimensions of innovation specifically related to people and organization, markets, and relations, knowledge and integration meanings and experiences (e.g., De Martino et al., 2013, p. 124).

While hard skills are technical skills that need the use of equipment, data, software etc., soft skills on the other hand, represent intrapersonal skills such as the ability to managing the different resources in port as well as the interactions taking place between port operators (e.g., Laker and Powell, 2011). Hard skills represent technical skills that can be acquired through specific training courses, easily quantifiable. Conversely, soft skills, known also as "people skills" or "interpersonal skills" are subjective skills that are much harder to quantify, but however able to affect the port context: communication, flexibility, leadership, team work, time management represent some of the main soft skills necessary for relationship.

Ports, despite the never-ending need for hard skills and therefore for a continuous updated software, suitable equipment, correct data and information require also soft skills in order to maximize their efficiency and gaining a greater market share respect to competitors. Therefore, port's success is subject, ceteris paribus, to the appropriate mix of hard and soft skills. Critical parameters in port workers employment nowadays is their adaptability in deployed in several parts of the port production chain as well as their ability to cooperate with the other players of the port community (i.e. port operators, port users' etc.).

3. FUTURE CHALLENGES TO BE ADDRESSED BY PORT WORKERS

The expected transition "from strength to skill" in the field of port labour will require new hard and soft skills for workers, thus increasing the need for specific training schemes and certifications. In the current port context there is a need for: i) highly skilled personnel; ii) new capabilities for port labour; iii) exploiting the human machine interface; iv) reviewing the role and the skills of port labour. In a port environment where the use of Information and Communication Technologies is advancing along with the introduction of automation and robotization, there are new needs regarding port personnel. On the one hand there are needs for highly skilled personnel who can design and develop technologically advanced tools and on the other hand there are needs for port personnel who can use and operate these tools. Due to the introduction of these new tools, a port's personnel must be well equipped with new capabilities. In this context, human machine interface becomes an important factor of competitiveness with port personnel being able to exploit machines in the best possible way, in order to ensure greater port efficiency. As such, a review of the role and the required skills of port personnel is needed.

3.1 New skills: developing purpose-made training courses

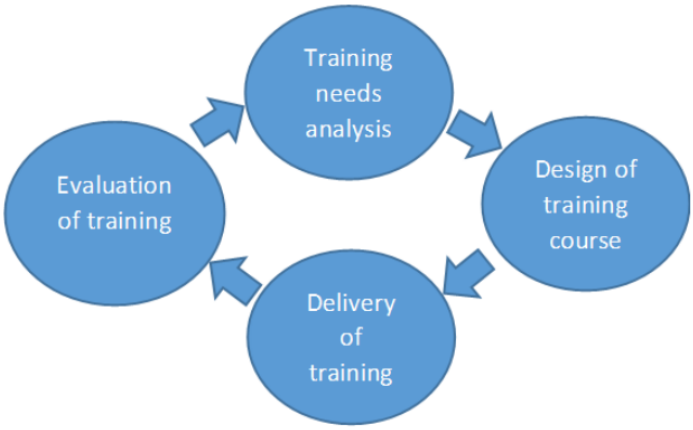
Port development goes hand in hand with technological development although the cause-and-effect relationship is unclear. For some, port development is the outcome of technological development while for others technological development is imposed by the need for port development. Apart from the new skills, the contemporary port environment creates also managerial and business cultural challenges. These close ties ask for new educational and training schemes and qualifications for port personnel, aiming at being able to adjust to the new port needs.

The training needs should focus on: i) the changing nature of port jobs and the skills required by the new port reality ; ii) the technological products, services and tools that can be applied in a port iii) the self-development; iv) Towards multi-task workers and multi skilled operations in ports; v) new career prospects in the port industry.

First of all, ports must redefine the critical skills required for port labour due to the many changes that have occurred in the port context as a result of technological, operational and organizational developments (i). Following the continuous advances in technology, purpose-made training courses have to be developed in order to keep up with path-breaking innovations (ii). The self-development of port personnel takes place through a process of experience and knowledge building especially in a new port environment (iii). Digitalization and automation in the contemporary shipping and port industries require fewer workers, but able to be more flexible and to perform various tasks; for this reason, multi task workers and multiskilled operations are becoming more common in ports (iv). Thanks to these developments new career opportunities in the port area are emerging; for example software and hardware engineers will be core professions for ports in the short term along with programmers, designers etc (v).

Training needs are fulfilled through a holistic training approach consisting of different phases: 1) Training needs analysis; 2) Design of training course; 3) Delivery of training; 4) Evaluation of training (see figure 1).

Figure n.1 - Training cycle



Source: Based on Northern Ireland Business (2019)

The first step of the training cycle includes the analysis of the training needs based on the port's strategy and goals, in order to identify the critical skills and knowledge that the port personnel must get. In this phase a customised approach is needed, designed to unveil the skills and competencies of each employee as well as each employee's training needs. Following that, the second phase deals with the design and the development of the training courses in the most suitable way, according to the port's and the port personnel peculiar needs. At the third phase of the training cycle the training is applied to the port personnel. Finally, the fourth phase of the process deals with the evaluation of the training program by both the port managers who supervised the program as well as from the participants in the program. The feedback is a critical input for evaluating the success of a training program, identify deficiencies that might be spotted during the training scheme and propose solutions which conclude (if its needed) in the redesign of the training program.

3.2. Certifications

From a labour-intensive industry in the pre-70's period, ports turned to capital intensive and in nowadays port industry is a technological intensive industry where innovation, knowledge and information sharing, all playing key role in port's efficiency and competitiveness. New tasks emerged which calls for new jobs and consequently for new port employees able to deal with the new job descriptions. Taking into account the complexity of the new automated port processes, the personnel must be well trained and of course certified for their skills and capabilities.

Regarding the certifications, although is an emerging issue in the contemporary port industry, it lacks of harmonization not only at a country level but even at a port level, where each port operator

has its own certification scheme and requirements. The lack of common job descriptions, skills requirements and training characteristics are the major causes. Each terminal operators and port authority have its own certification mechanisms, with their own certification needs for each port labour task. Although in some cases there is a harmonized approach in national level for the certification of some port labour tasks (for example in Greece there is a related law by the Ministry of Shipping and Insular Affairs), the reality is that there is a plethora of certification schemes based on the training needs, the requested skills and the port jobs description at port/terminal level.

A harmonised approach towards port labour certification is a challenge that the port industry has to deal with. Port jobs need to be certified aiming at:

- ensuring a minimum level of quality;
- creating a common port labour market;
- allowing mobility of port labour (for example in the EU's port market).

The uniformity of a common approach at least at European level would safeguard a minimum level of quality standards for all EU ports and will further open the EU port labour market. Furthermore, common certification schemes will allow for the mobilization of port labour in the European port industry.

3.3. Social awareness

With an increasing social awareness regarding port activities, port related labour couldn't be left out of the discussion. Social awareness is defined as "the ability to take the perspective of and empathize with others from diverse backgrounds and cultures, to understand social and ethical norms for behaviour, and to recognize family, school, and community resources and supports" (e.g., CASEL, 2017).

To better facilitate social awareness, European Commission launched the European Social Dialogue for Ports on June 2013, aiming at discussing issues of European social reference for the port sector. The program is mainly focus on health and safety matters related with port work as well as training and qualifications schemes for port labour. Also, the dialogue focus on issues related with port employment with an eye on the attractiveness of the sector to young workers and gender issues.

4. PROS AND CONS OF THE TECHNOLOGICAL DEVELOPMENT IN PORTS

Grounding on some empirical cases extrapolated from the port industry, the paper demonstrates that the expected transition "from strength to skill" in the field of port labour will require new hard and soft skills for workers, thus increasing the need for specific training course and certification schemes. A question. still to be answered, both by the academia and the industry, deals with the expected benefits by the adoption of automation, digitalization and in general technological development by the port industry, outweigh the related costs (necessary investments, cost of training schemes, cost of high skilled personnel etc.). Table 1 presents the evolution in specific port labour and port operations characteristics through the adoption of automation and the increased use of technological solutions in port operations.

Table n. 1 - The evolution of port labour

From	Towards
Single skilled labour	Multiskilled/specialist workers
Labour intensive operations	Capital-Technology intensive operations
Port/terminal-based certification schemes	Harmonized certification schemes
Casual hiring	Permanent employment
Informal on-the-job training	Formalized training
Male workforce	Gender equality

Source: Author

Contemporary ports are characterized by capital-intensive and technology-intensive operations instead of previous labour-intensive operations. This is a fundamental trend within a competitive environment where technology, in the past, was not considered the key driver of port success. Port labour hiring schemes are also changing, moving towards more stable forms of employment under permanent contracts especially for the high-skilled personnel, instead of a port context previously characterized mainly by the stipulation of casual labour hiring

Training for the different tasks to be performed in the port context is also evolving from informal, on-the-job training to formalized training. The new skills to be acquired for better response to future changes in the port area ask also new educational and training schemes as well as qualifications for port personnel, aiming at being able to adjust to the new port needs. Obviously, the increasing presence of technological tools in the ports allows to employ not only male workers but also female workers creating a more diversified labour force.

The aforementioned evolutions develop a new port labour environment. Table 2 summarises the major pros and cons of the technological development in ports vis-vis port labour.

Table n. 2 - Advantages and disadvantages of technological development for port labour

Advantage	Disadvantage
+ increasing demand for new highly-skilled workforce	- jobs security – loss of low skilled jobs
+ increasing health and safety conditions	- changes in jobs description
+ increasing labour productivity	- jobs are becoming more mentally demanding
+ strategic jobs: direct impacts on work flow, interdependent, non-substitutability	- flexible working conditions

Source: Author

The technological, operational and organizational development result in an increasing level of demand for new jobs and roles, with a focus on new hard and soft skills for port labour. Also, technological evolution creates better health and safety conditions in port's workplaces, with increasing labour productivity, thanks to a regular monitoring of port operations and security systems applied in the port context in order to comply with the most stringent safety and security regulations. Another effect is the creation of strategic jobs with direct impacts on the work flow, characterized by elements such as interdependency and non-substitutability. On the other hand, the evolution of port

labour brings disadvantages such as the loss of jobs, especially low-skilled jobs, and changes in jobs description due to the different skills imposed by such trends as digitalisation and automation, triggering towards highly-skilled workforce. In addition, port jobs are becoming more mentally demanding.

The paper contributes on the ongoing debate on the challenges and the opportunities that technological development creates for port labour offering insights for both academics and practitioners.

The study provides a first conceptual framework for addressing the impact on digitalisation and automation on port labour. Table 3 synthetizes the overall conceptual framework proposed, highlighting the implications of technology-driven trends such as digitalization and automation, in port labour, in line with the two research objectives of the paper. In this perspective, both potential advantages and disadvantages affecting port labour are identified.

Table n.3 – Conceptual framework: implications of digitalization and automation in port labour

Advantages of digitalization	*Advantages of automation*
+ increasing port efficiency	+ increasing port efficiency
+ improving future planning and management of real time information	+ increasing productivity and quality in port-related processes
+ increasing port responsiveness to port users' needs	+ increasing standardization of port operations
+ increasing monitor and control operations	+ robotization
Disadvantages of digitalization	Disadvantages of automation
-loss of low skilled jobs	-yard requirements
-jobs are becoming more mentally demanding	-shortage of specialised technical personnel
-flexible working conditions	-lack of data and data quality
-increasing initial investment cost	-increasing initial investment cost

Source: Author

Despite the contribution to the topic of port labour, it is not yet possible to provide a complete overview of all the variables expected to be affected by automation and digitalization. New requested skills related to each port task, innovative training courses to be set and developed, in fact, have to be further investigated and the different impacts on skills and competences characterizing the industry in the new era need additional empirical investigations. Future contributions are also expected to shed lights on training programmes to be developed for different type of professional profiles as well as port and maritime tasks.

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